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THE USE OF BRINE TANK REFRIGERATOR CARS FOR FRUIT SHIPMENT

BY

EDWIN SMITH, B.S.A.

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LETTER OF TRANSMITTAL.

To the Honourable the Minister of Agriculture.

Sir,—I beg to submit for your approval the manuscript of a report of investigations into the use of "brine tank" refrigerator cars in the shipment of fruit, which were carried out under the immediate supervision of the author, Mr. Edwin Smith, B.S.A., formerly in charge of the Precooling and Experimental Fruit Storage Warehouse at Grimsby, Ont. The railway companies include in their equipment a number of these cars intended primarily for the carriage of meats at a low temperature. As many of these cars loaded with meats and dairy produce are sent into some of the fruit growing districts, it is important to know if they can be used to advantage to carry fruit as a return load and thus effect a considerable economy in car mileage.

This report gives the results of trial shipments made in British Columbia and also in connection with the operation of the Grimsby warehouse.

Some results already published in Bulletin No. 48 have been summarized and included in this report thus bringing all our data into one document for the convenience of those who may be interested in the subject.

I have the honour to recommend that this report be published as Bulletin No. 50, Dairy and Cold Storage Series.

I have the honour to be, sir,
Your obedient servant,

J. A. RUDDICK,
Dairy and Cold Storage Commissioner.

Ottawa, January 30, 1917.

THE USE OF BRINE TANK REFRIGERATOR CARS FOR FRUIT SHIPMENTS

BY

EDWIN SMITH, B.S.A.

Growers and shippers of fruits and vegetables have strongly objected to the brine tank refrigerator car for the shipment of their products. Their objections are fairly based upon unsatisfactory experiences and heavy losses incurred owing to high temperatures in shipments made with this type of refrigerator car. The railways of Canada have found this car admirable for shipping such perishable produce as poultry, meats and dairy products that require low temperatures, and, as the shipping of fruits covers only a portion of the year, and a dual purpose car has been required, they have favored its adoption. With shippers and consignees ruling against, and often refusing to accept these cars for shipment, and the railways increasing their supply, a problem has been presented to the Department of Agriculture which has resolved itself into the work of making the brine tank refrigerator car efficient for the shipment of fruits and vegetables. Since the season of 1913, when the investigational work was started, great progress has been made toward this end, so that at the present time many very satisfactory shipments of tender fruits are being made in brine tank cars, and shippers who understand the proper methods of using them are accepting them for such shipments without complaint.

In using the brine tank refrigerator car for shipments of dressed meats or poultry, it has been customary to use from 10 per cent to 20 per cent of crushed rock salt mixed with the ice. This melts the ice rapidly, removing the heat from the interior of the car and causing temperatures to fall below freezing. By the continued use of salt in re-icing, freezing temperatures are maintained in the car during transit even in hot weather. When fruit shipments were undertaken in these cars, the use of salt was omitted, through the supposed danger of freezing, the ice being put in the tanks in block form, similar to the method of icing the bunker or block-ice type of car. Herein lies the error which has led to the unpopularity of brine tank cars among fruit shippers.

When the ice is placed in the tanks in large blocks, melting takes place very slowly, because it is in a separate compartment, completely shut off from the hot air that would naturally circulate from the warm fruit, melting not taking place until the heat has been transmitted through the iron tanks. It should be more clearly understood that ice has to melt to have its refrigeration made available for the cooling of a refrigerator car in just as real a sense as coal has to burn to make its heat available. The result of such methods of icing the brine tank car gave very high temperatures with a consequent deterioration of the fruit. Thermographs placed in brine tank cars iced in this way show that the temperature seldom goes below 50° F. The thermograph record shown below is a fair sample of such shipments. This shipment was made

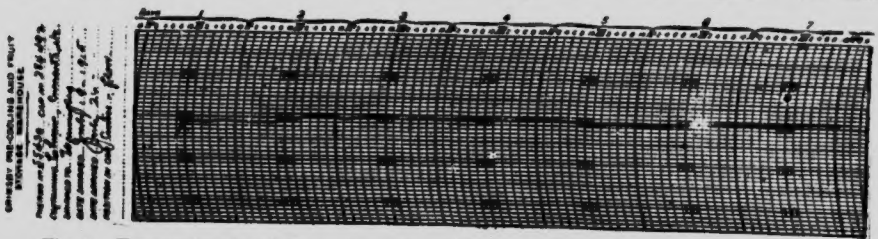

Fig. 1. Temperature in a brine tank car, in which no salt was used. Car No. 284,492 C.P.

July 19, 1915, with currants, cherries, etc., precooled to 46° F. before shipment and shipped to Winnipeg in car No. 284492 C.P. It will be seen that the brine tank car did not furnish refrigeration sufficient to keep the temperature as low as it was at the start, so that a portion of the cherries showed a waste of 10 per cent upon arrival at Winnipeg.

The Use of Salt and Ice for Fruit Shipments in Brine Tank Cars.

(Summary of Previous Work taken from Bulletin No. 48.)

Co-operating with the Canadian Pacific Railway during the spring of 1914, tests were made in Vancouver using low percentages of salt, i.e., 2 per cent and 5 per cent of salt with crushed ice in empty brine tank cars. By using 2 per cent of salt, the temperature near the tanks reached 32° F. and in the centre of the car, 38° F. By using the 5 per cent of salt mixture, a temperature of 25° F. was secured near the tanks, and 32° F. in the centre of the car. While the 5 per cent mixture seemed to give a temperature too low for fruit, it should be kept in mind that the tests were made in the middle of April when the outside temperatures ranged from 40° F. to 65° F. With ten tons of warm fruit in the car, and an outside temperature of from 60° F. to 90° F. this low temperature would not be obtained. (Fig. 1.)

Following up this work in the summer of 1914 with a shipment of fruit from Summerland to Vancouver, B.C., a brine tank car was used with slatted floors and with 5 per cent of salt incorporated with crushed ice in the tanks. The shipment arrived in Vancouver in good condition. The temperatures were low and there was no evidence of freezing.

Demonstrations with Brine Tank Cars in 1915.

With the co-operation of the Canadian Pacific and the Grand Trunk Railways, arrangements were made to use brine tank refrigerators for two cars of fruit that where purchased for experimental shipment from Grimsby to Winnipeg during the past season, in order to carry the work further, using the salt mixture with precooled fruit.

Crushed ice with 5 per cent of salt was placed in the tanks of the cars. The fruit was precooled to 40° F. and 45° F. As is the customary practice at the precooling plant with all shipments of precooled fruits, slatted false floors were placed in the cars. A thermograph was placed on the floor against the ice tanks to record the lowest temperatures during transit and one was placed on top of the load of fruit in the centre of the car to record the highest temperature to which the fruit would be exposed while in the car. The fruit was loaded and braced in the usual manner and the doors sealed with sulphite paper. On September 20, car No. 284024 C.P. (Fig. 2) was shipped to Winnipeg, requiring four and one-half days to reach its destination. On September 23, car No. 340053 G.T.P. (Fig. 3) was shipped to the same point requiring approximately five days to reach its destination. Block ice without salt was used for re-icing during transit.

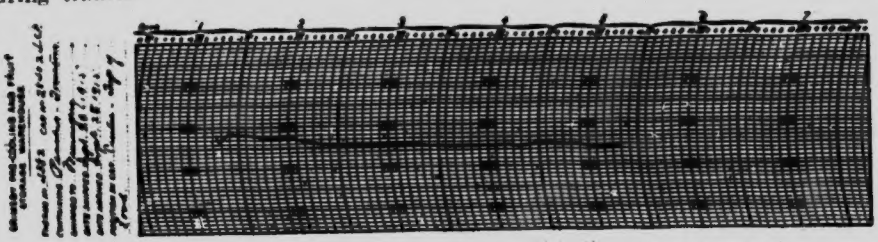

Fig. 2. Temperature record, top of load of fruit, centre of car No. C.P. 284,024.

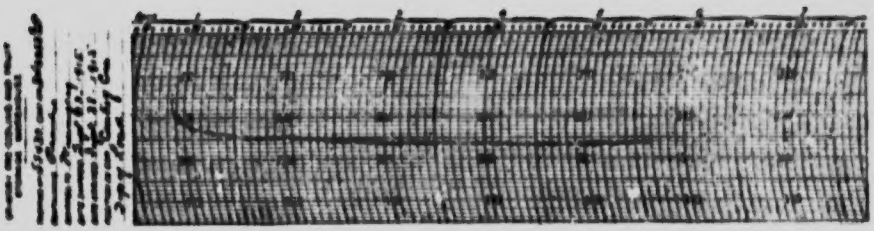

Fig. 3. Temperature record, top of load of fruit, centre of car G.T.P. No. 340,053.

Mr. A. H. Flack, Chief Fruit Dominion Inspector for the Prairie Provinces, inspected the shipments and reported that they arrived there in perfect condition. No injury whatever was to be seen from low temperatures and the highest temperature was as low as is ordinarily secured in refrigerator shipments. Copies of thermograph records are herewith shown, with the exception of that from the instrument on the floor near the bunkers of the car No. 284024 C.P., which failed to record.

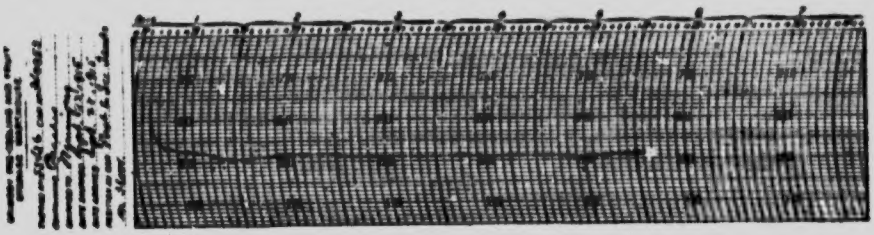

Fig. 4. Temperature record, against brine tanks, floor of car G.T.P. No. 340,053.

Investigations in 1916.

During the hot season of 1916 the inadequacy of ordinary refrigerator cars without the use of salt was very manifest. This is well shown in thermograph record 55426, made in an express shipment of raspberries in car No. 280532 C.P., July 26, from Grimsby to Winnipeg. The fruit was precooled to 38°-40° F. and in the two-day shipment, the temperature in the centre of the car on the floor rose to 50° F. notwithstanding that the car was under ice the entire way.

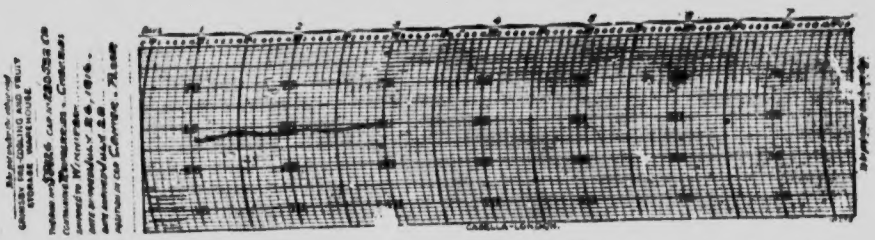

Fig. 5. Temperature record for precooled raspberries in car No. 280,732 C.P. July 26, 1916.

The first brine tank trial made in the season of 1916 was with No. 340120 G.T.P., Grimsby to Winnipeg, with sour cherries precooled to 43° F. Rock salt to the extent of 400 pounds was added previous to shipment, without instructions to use salt in

transit. The temperatures rose to 53° F. in the centre of the car during he trip, showing that simply adding salt at the initial icing was not adequate. The shipment resulted in a heavy loss.

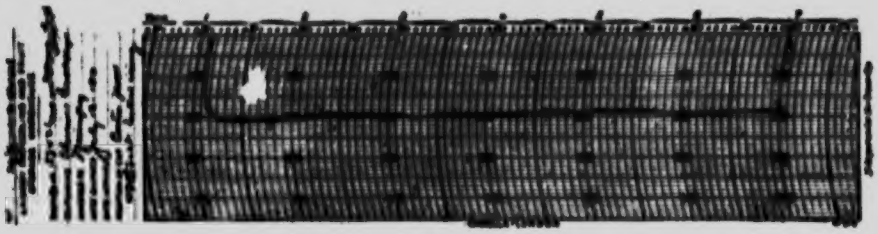

Fig. 6. Temperature record for precooled cherries in car No. 340,120, July 12, 1916.

On september 12 brine tank car No. 286076 C.P. was shipped from Grimsby to Brandon, containing fruit precooled to 39° with instructions to use 5 per cent salt in re-icing. Records from thermographs placed next to the bunkers and in the centre of the car show gratifying results. Non injury from low temperature occurred and the fruit arrived in splendid condition.

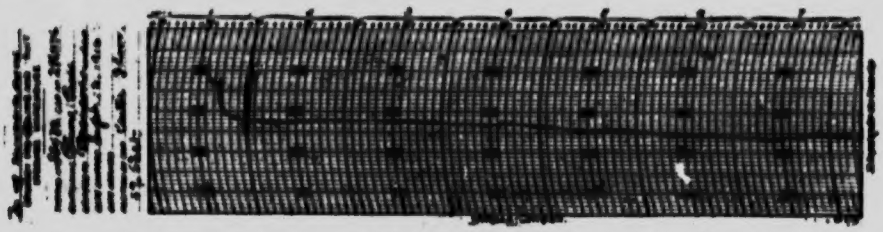

Fig. 7. Brine Tank Refrigerator Car No. 286,076 C.P., 5 per cent salt used in re-icing. Thermograph record made on floor in centre of car.

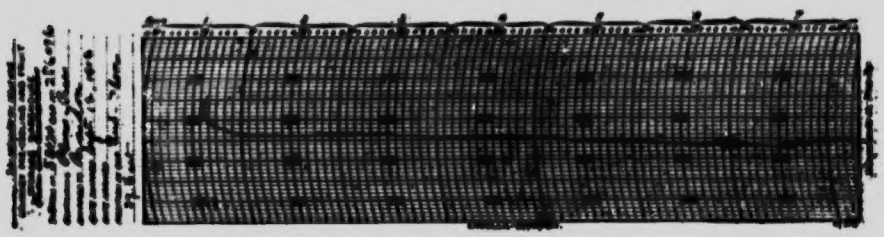

Fig. 8. Thermograph made on floor in end of car No. 286,076.

Similar instructions were issued with brine tank refrigerator car No. 286071, shipped September 13 to Deloraine, Man. The temperature in the centre of the car is shown herewith.

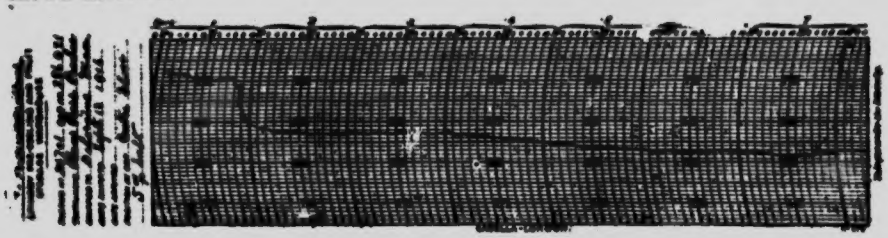

Fig. 9. Record of Brine Tank Car No. 286,071 to Deloraine, Man.

While these investigations have not gone far enough to test the efficiency of the insulated bulkhead, it would appear to have the advantage over the fan system by allowing the fruit to be on the road 24 hours sooner,—cooling taking place while rolling.

Results indicate the advisibility of using heavier mixtures of salt with the ice to secure quicker melting of the ice and a more rapid cooling of the fruit.

It is necessary to emphasize the need of caution regarding the use of salt with the ice in refrigerator cars unless ample space is given for the cold air to flow towards the centre of the car. Floor racks at least 4 inches from the car floor and with an open throat to the bunker should be provided. If more than 8 per cent of salt is added, precaution in way of insulation should be taken to prevent freezing near the ice.

Floor Racks, End Bulkheads and Splash-boards.

In cars 286076 and 286071, end bulkheads, which allowed a 4-inch space between the fruit and the permanent bulkheads in the car, were installed. This allowed a free circulation of air to pass from around the cold brine tanks underneath the false floors to the centre of the car to replace the warm air. Refrigerator cars loaded with fruit should not be shipped with salt mixtures, unless false floors are used, so as to allow the cold air about the bottom of the tanks to flow freely away, and to be replaced by the warm air coming from the fruit, the temperature of which will be reduced in turn. Danger from freezing in the proximity of the tanks is imminent if efficient false floors are not used.

The Canadian Pacific Railway has been making progress in building improved refrigerator cars of the brine tank type, the most notable improvement being in the permanent raised floor racks that are slatted and allow a five inch space beneath the load for the cold air to circulate from the ends towards the centre of the car. These cars also have ample vents in the tanks so that shipments may be sent under ventilation when so desired. Cars No. 286076 C.P., and 286071 C.P., were of this type.

Aside from needed improvement in the insulation and floors of the general run of refrigerated rolling stock, this bulletin is to emphasize especially the improvements needed to carry the refrigeration from the bunkers or brine tanks to the centre of the car. In past refrigerator car practice, it has been common to load packages of fruit squarely up against the bunkers and trust to the cold air reaching the centre of the car through insignificant cracks or spaces between the fruit packages. The impossible was expected when cold air was to be carried fourteen feet through spaces between packages of warm fruit and have it keep the centre of the car cool. In such cases the result has been that the fruit near the ice cooled down, but that farther away has remained warm throughout transit. Even with precooled fruit it has not been possible to conduct ample refrigeration to the centre of the car to overcome the transmission of heat through the doors and insulation, so that temperatures actually raise while the car is under ice.

First of all refrigerator cars are in need of an open space underneath the load from the ice to the centre of the car, and this is accomplished by having slatted floors placed permanently in the cars from four to six inches above the insulated floor of the car. This space *must have an open throat* to a space about the ice or the brine tanks. In most refrigerator cars at the present time (the newest types with permanent floor racks are also subject to this criticism), a splash-board is constructed high enough and near enough to the load to shut off the free passage of air. In diagrams 1 and 2 pages 12 and 13 is shown the result when fruit is loaded in the car. The cold air is dammed up before it can reach the open channel made by the floor racks. The importance of this has been thoroughly demonstrated; heat must travel by convection currents to make rapid progress, and the benefits of floor racks will be lost if they are not rendered efficient at their throats. In diagram 3 on page 14 is shown the splash-board properly located. In making shipments in car No. 286076 C.P., and 286071

C.P., such a throat was made by ripping up a slat of the floor and installing an end bulkhead as shown in diagram 4 on page 15. This allowed a free circulation of air about the whole load and resulted in satisfactory temperatures.

Once the car is constructed so that refrigeration may be conducted to the centre of the car salt may be applied freely to the ice in order to release the refrigeration quickly,—the colder the air being in one part of the car, the more active will be the circulation of air to the warmer parts.

Without the use of salt with crushed ice the brine tank refrigerator car is inefficient and unsatisfactory for use with fruit shipments.

The use of 5 per cent salt with crushed ice in conjunction with slatted floor racks has improved the temperature conditions in brine tank cars. With these methods a good brine tank car has given very much more satisfactory results than a poor block-ice car.

Neither freezing nor injury from low temperatures occur with the use of 5 per cent salt with crushed ice when slatted floor racks are used. The floor racks prevent the damming-up of the cold air at the base of the tanks and allow it to flow freely to the centre of the car.

All obstacles blocking the opening between the tanks and the space underneath the floor racks should be removed. Where splash-boards permanently block the opening end bulkheads, providing such an opening, should be used.

It is necessary for shippers to closely follow the methods outlined in loading cars and to include in their icing instructions on the bill of lading "Re-ice, using 5 per cent salt with crushed ice."

It is necessary for the railway companies to provide icing stations with crushed rock salt and facilities for crushing the ice. It is to their interest to encourage the proper loading and billing of these cars and to give them special attention at all icing stations.

New System of Pre-cooling.

Theoretically it is necessary to use 2·1 tons refrigeration to remove heat sufficient to lower the temperature of 20,000 pounds of fruit from 80° F. to 40° F. In actual practice from 3 to 5 tons refrigeration are required to do this amount of cooling, depending upon the efficiency of application. The difference between 2·1 tons refrigeration and the actual amount used in practice is taken to offset loss through heat from friction, heat in equipment and transmission of heat through insulation.

The average refrigerator car has space for 4 tons of ice (refrigeration). In the past, unless the fruit has been precooled, the outstanding fault of a refrigerator car has been the extreme length of time (two to five days) required to make this amount or refrigeration available for the cooling of the fruit. By the use of salt mixed with the ice it is possible to make this amount of refrigeraton available in from 24 to 30 hours from the time the ice is placed in the car and, if the refrigeration is properly carried to different parts of the car, effect a cooling of the fruit, but if the refrigeration is not thoroughly distributed throughout the car and the fruit nearest the source of refrigeration is not properly protected, the result will be frozen fruit in the ends of the car with warm fruit in the centre.

The principle of this system of precooling is to secure refrigeration in quantities great enough to cool down the load of fruit in the 24 hours following loading by mixing salt with ice and to properly distribute the refrigeration by means of floor racks, end bulk-heads and either electric fans or natural circulation through gravity. Protection from freezing by radiation of heat from the fruit nearest the bunkers to the melting ice may be effected by having the end-bulkheads insulated, or by having them constructed so as to leave an air space between the fruit and the bunker with a covering of paper to deflect the air currents from passing directly through the fruit. The air currents passing downward through this space carry warm air and prevent

freezing. With our investigations thus far the end-bulkheads have been made with a 4-inch air space with two-ply of building paper on the side nearest the fruit, overlapping at the sides and bottom. Tests have been made both with using electric fans to circulate the air and by using natural circulation by gravity, allowing the car to stand on the track for 24 hours while cooling.

Experimental work was started with this system in April of 1916, by placing an empty brine tank refrigerator at Grimsby and icing it with crushed ice and 5 per cent and 10 per cent salt mixture. The car was equipped with paper-lined end-bulkheads and false floors four inches from the floor, so that a duct for continuous air circulation was made from the top of the bulkheads to the bottom and centre of the car. This test was made to determine if sufficient air current could be established to equalize the temperature at the ends of the car with that at the centre to such a degree as to prevent freezing at the end and cause sufficient cooling in the centre of the car.

One end of the car was loaded with empty peach boxes in the customary manner. By means of mercurial extension thermometers and thermographs, the temperatures were taken at the floor near the bunkers, and at the top of the load in the centre of the car. A 16-inch electric fan was placed about four feet from the ice bunker near the roof, sending the warm air towards the ice.

The test showed that with 5 per cent salt only a short time was required for the 16-inch fan to bring the temperature in the centre of the car to that at the base of the brine tanks. Using 10 per cent salt the temperatures were equalized to within one degree, the warm air in the centre of the car displacing the cold at the base of the tanks and distributing it about the fruit packages. By using 10 per cent salt in one end and an oil heater in the centre of the car to unbalance temperature conditions as far as possible, upon operation of the fan, temperatures were again equalized to within one degree.

Using 10 per cent salt mixtures in both ends of the car, the minimum temperature was secured in the *centre* of the car while operating the fan. This temperature was 31½ degrees. The capacity of the system to replace the cold air near the tanks with the warm air near the centre of the car was here shown when temperatures at the top of the load in the centre were maintained at a lower point than at the bottom near the tanks. Without using the fan about 7° F. difference was observed between the temperature at the end of the car and in the centre.

These observations gave encouragement that resulted in making tests in September with loaded refrigerator cars using this system of precooling. Three cars were shipped from St. Catharines to Winnipeg and two cars from Grimsby to Camrose, Alta.

At both places cars were equipped similarly. Floor racks were constructed 4 inches from the regular car floor. End-bulkheads were constructed 4 inches from the permanent bunker bulkhead to a height equal to that of the load of fruit. This bulkhead was lined with two ply of building paper. The car was loaded to the centre and braced, leaving a space in the centre for air circulation. A study of diagram 4 on page 15 will show clearly the methods employed, and that an open space completely surrounds the load of fruit, providing free passage-way for air circulation. The 16-inch fans were used at periods, depending upon the amount of fruit in the car and upon the amount of salt used with the ice. The cars were iced at the time of loading, the ice being either broken up or crushed to secure a more satisfactory mixture with the salt.

On account of the long period of loading required at St. Catharines, but from 6 per cent to 8 per cent salt was used with the ice and the fans were scarcely used at all. At Grimsby the fruit was placed in the car, icing done with 8 per cent salt and the fan operated for 24 hours. The latter results were more satisfactory as will be shown by the thermograph records which tell the story graphically.

The fruit cooled in these cars registered 64° F. up to 70° F. at the time of placing in the car. This temperature is from 10° to 20° lower than would be the case in July.

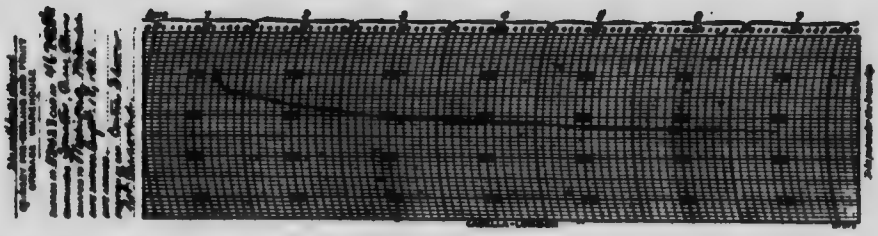

Fig. 10. Temperature record in car No. 46796 G.T. shipped from St. Catharines, September 18, 1916, without precooling. Temperature taken in centre of car on the floor. Typical of a non-precooled shipment.

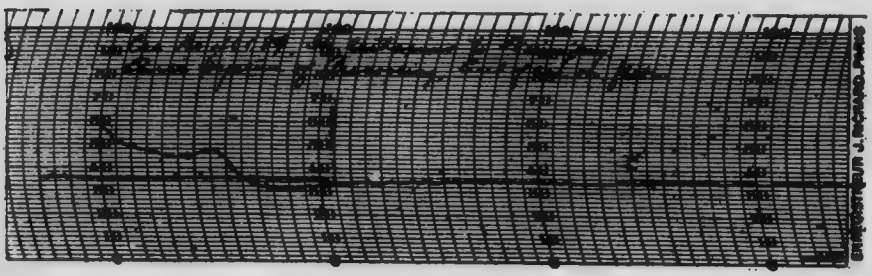

Fig. 11. Temperature record in car No. 46,639 G.T. Shipped from St. Catharines, September 16, 1916, car precooling. 6 per cent salt used. No salt used in transit. Thermograph placed in a basket on the floor of the car against the end bulk-heads.

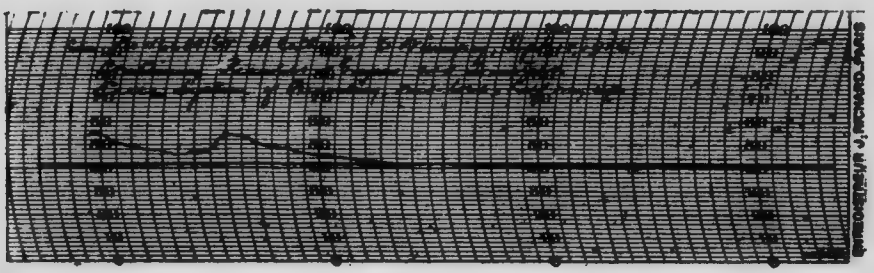

Fig. 12. Temperature record in car No. 46,639 G. T. Thermograph placed in a basket half way between floor and top of load; half way between ice bunker and centre of car.

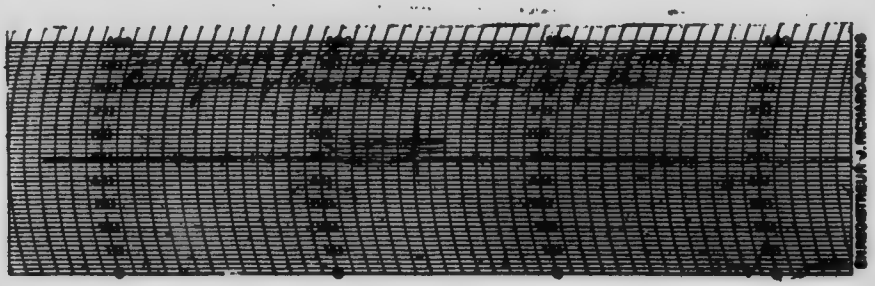

Fig. 13. Temperature record in car No. 46,639 G.T. Thermograph placed in a basket in the top tier of the load in the centre of the car.

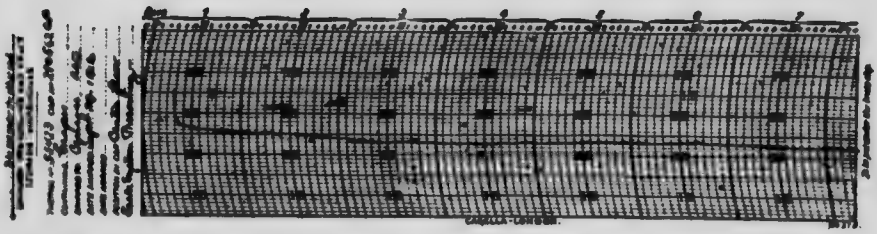

Fig. 14. Temperature record in car No. 280,562 C.P. Shipped from Grimsby to Camrose, Alta., September 29, 1916. Car precooling. 8 per cent salt used. No salt in transit. Thermograph placed on the floor in centre of the car.

Reports on the cars showed that they arrived at their destination in perfect condition, although this is partially due to the cool weather in September and to the kinds of fruit shipped (peaches, tomatoes, pears and grapes.) The McNaughton Fruit Company of Winnipeg stated that car No. 46689 G.T., was the most satisfactory car of fruit they had ever received from the Province of Ontario.

In studying the thermograph records, it will be seen that car No. 280562 C.P., maintained an exceptionally good temperature. Shipments at this time of year meet with cool weather, which has to be taken into consideration in applying the results to July conditions.

Conclusions.

The results of the first season's tests show that it is possible to precool fruits in cars using for refrigeration the ice in the bunkers without loss from freezing. The range of cooling in the tests was not as great as desired, this being the result of not using heavy enough salt mixture.

By using an electric fan in each end of the car for 24 hours previous to shipment, the cooling in the centre of the car is equalized with that in the end of the car.

It is safe to use up to 10 per cent salt with crushed ice, but if heavier mixtures are used, experience suggests that either insulated bulkheads be used between the fruit and the ice or else fans used to circulate the air, causing the warm air from the centre of the car to flow down through the end bulkhead air space between the fruit and the ice.

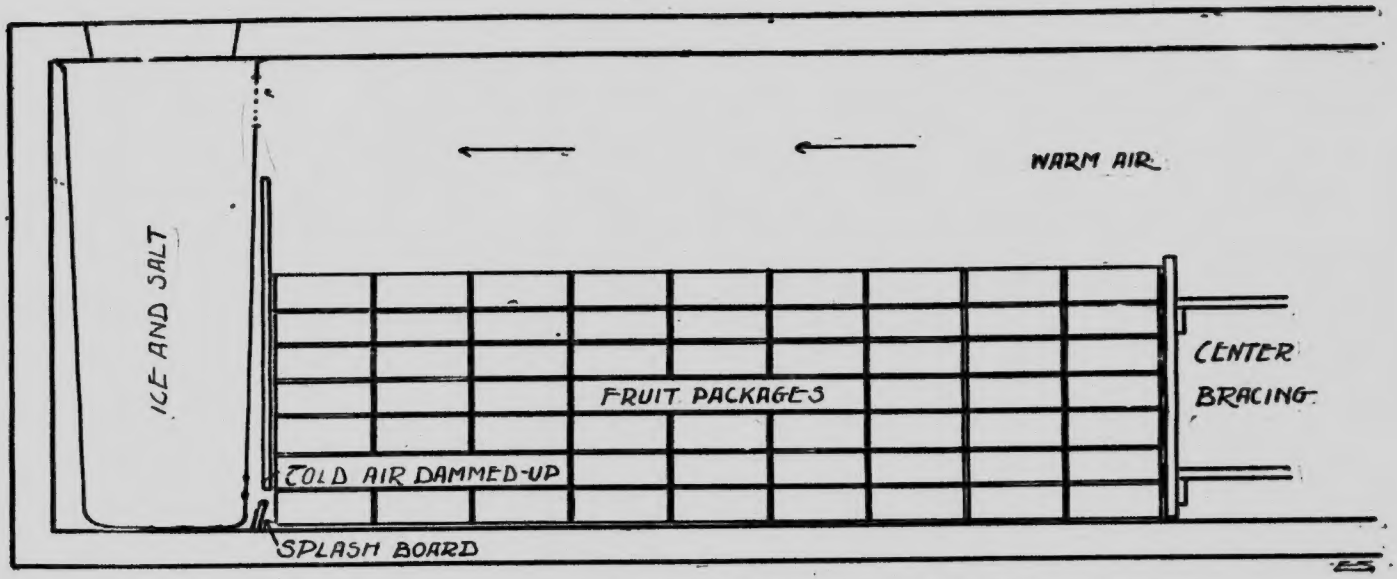

Diagram 1. Showing wrong arrangement of splash board in brine tank cars which prevents free circulation of air.

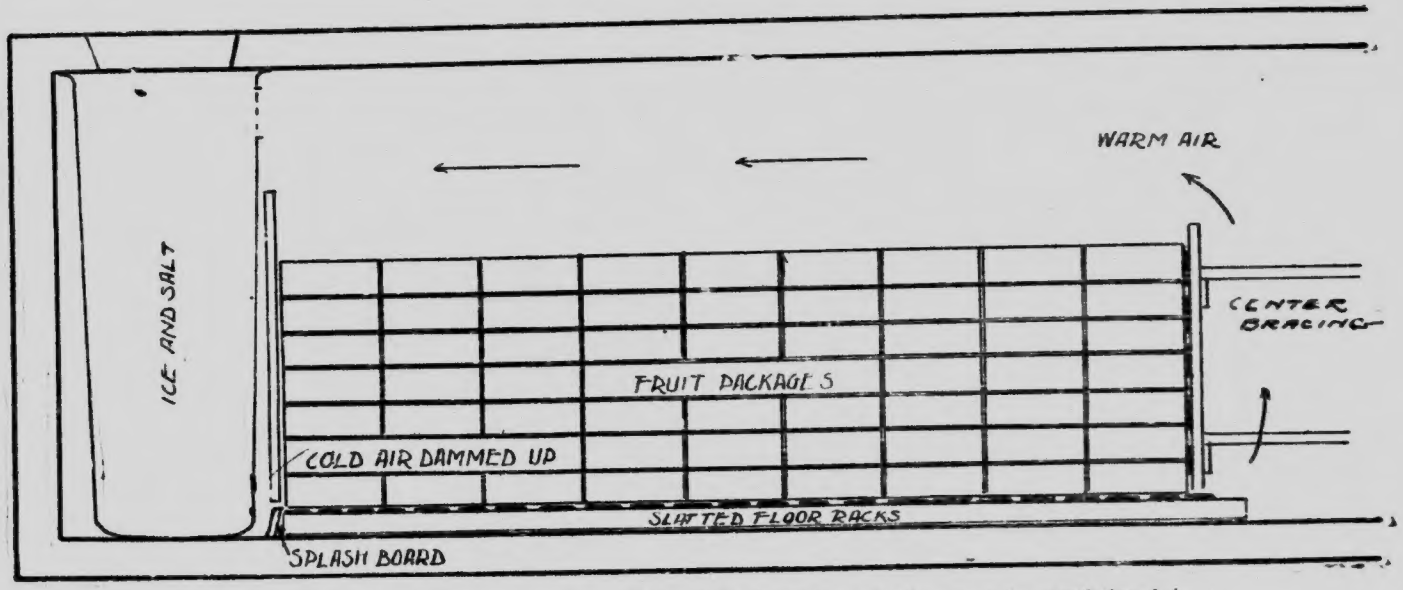

Diagram 2. Showing wrong arrangement of splash board in brine tank cars which prevents free circulation of air.

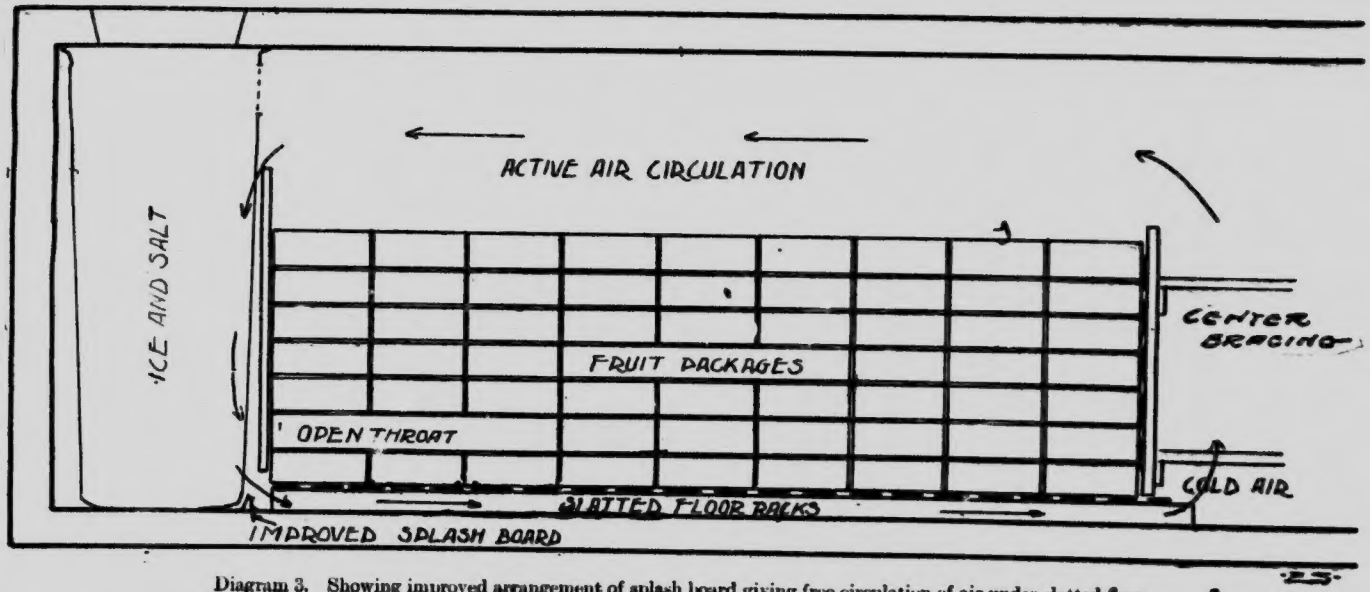

Diagram 3. Showing improved arrangement of splash board giving free circulation of air under slatted floor.

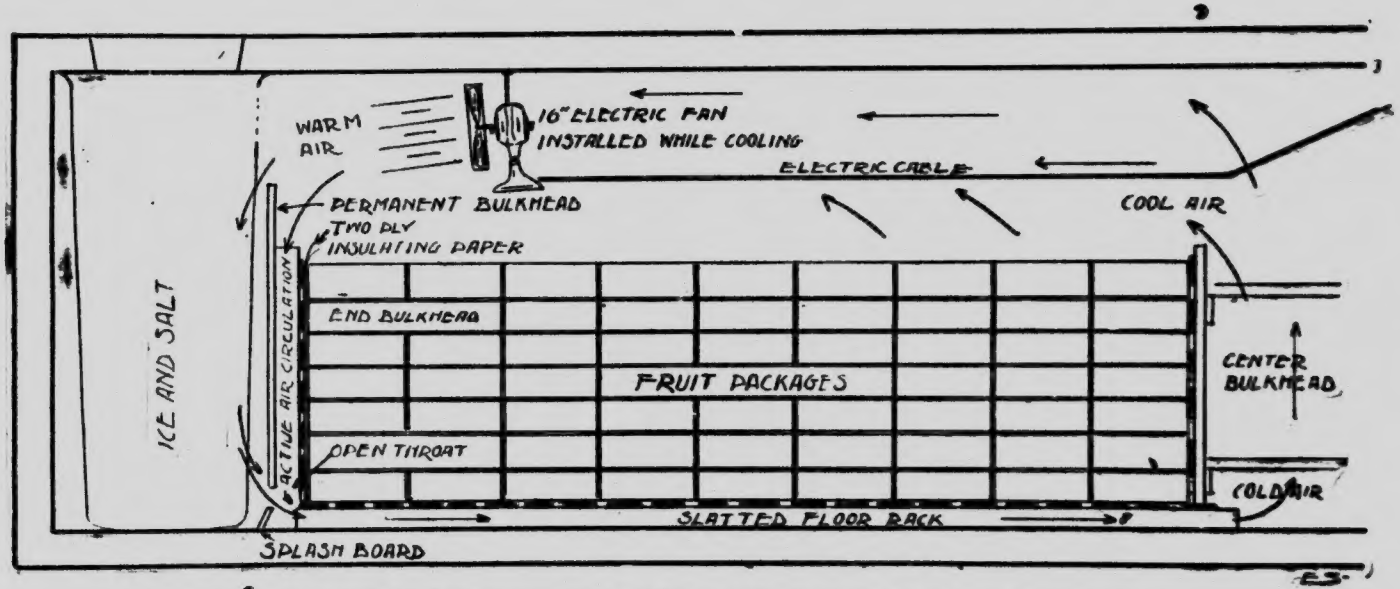

Diagram 4. Showing arrangement for circulating air with electric fans after car is loaded.